

Deep Carbon Cycling Due to Mélange Diapir Melting

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The carbon cycle between Earth's surface and its deep mantle directly affects Earth's ecosystems and its habitability. The melting of a mélange diapir is a new petrogenetic model for the origins of alkaline arc igneous rocks. However, as an important form of material recycling in subduction zone, the deep C cycle related to mélange diapir melting is poorly understood. We investigate the decarbonation related to mélange diapir melting based on major and trace elements, and Sr–Nd–Pb–Zn–Mg isotopic data for the Oligocene alkaline rocks in northeast China. These rocks consist of plagioclase-bearing and plagioclase-free trachyandesite, and aegirine–augite syenite. The Oligocene alkaline rocks have relatively concentrated SiO₂ (56.10–58.96 wt.%) and high alkali (Na₂O+K₂O= 9.72–10.82 wt.%) contents, which show a similar trend to the experimental melts of natural mélanges. From trachyandesites to syenites, the REE and trace element abundances increase, and the high-field-strength element contents change from depleted to enriched. These characteristics are indicative of interactions between carbonated mantle and a mélange. Their Sr–Nd isotopic compositions and variations in Hf/Nd ratios indicate the alkaline rocks formed by partial melting of a mélange diapir. The heavy Zn isotopic compositions ($\delta^{66}\text{Zn} = +0.35\text{‰}$ to $+0.44\text{‰}$) of the alkaline rocks, combined with the Nb–Ta enrichment of the syenites, reflects the contribution of carbonate components during melting of the mélange diapir. The Sr–Zn isotopic modeling results suggest that the species of carbonate was magnesite (>90%). However, the alkaline rocks have heavy Mg isotopic compositions ($\delta^{26}\text{Mg} = -0.30\text{‰}$ to -0.03‰), implying that dehydration of the subducted mélange occurred before melting. The correlations between major and trace elements and $\delta^{66}\text{Zn}$ values show that altered oceanic crust contributed most of the carbonate during decarbonation, which means previous studies have overestimated the contribution of subducted sediments during the decarbonation of a diapir. Mélange diapir melting had an important role in driving the deep C cycle in northeast Asia during the Cenozoic.

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